USER CONFIGURABLE ALARMS AND ALARM TRENDING FOR PROCESS CONTROL SYSTEMS

Related Applications

[0001] This application is a regular filed application of and claims, for the purposes of priority, the benefit of U.S. Provisional Application Serial No. 60/567,980, entitled "Graphical User Interface for Representing, Monitoring, and Interacting with Process Control Systems," which was filed on May 4, 2004 and which this application hereby expressly incorporates by reference herein in its entirety. This application is also related to U.S. Patent Application Serial Number 10/625,481, entitled "Integration of Graphic Display Elements, Process Modules and Control Modules in Process Plants," which was filed on July 21, 2003, and which published as U.S. Publication No. 2004/0153804 on August 5, 2004, which, in turn, is a Continuation-in-Part of U.S. Patent Application Serial No. 10/278,469, entitled "Smart Process Modules and Objects in Process Plants," which was filed on October 22, 2002, and which published as U.S. Publication No. 2004/0075689 on April 22, 2004, the entire disclosures of which are hereby expressly incorporated by reference herein in their entirety. This application is also related to U.S. Patent Application Serial Number 10/368,151 entitled "Module Class Objects in a Process Plant Configuration System," which was filed on February 18, 2003, and which published as U.S. Publication No. 2004/0199925 on October 7, 2004, the entire disclosure of which is hereby expressly incorporated by reference herein in its entirety. This application is also related to the following patent applications, which are being filed as International (PCT) applications on the same date as this application and which this application hereby expressly incorporates by reference herein in their entirety: "Associated Graphic Displays in a Process Environment" (Atty. Docket No.

06005/41111); "Integration of Process Modules and Expert Systems in Process Plants" (Atty. Docket No. 06005/41113); "A Process Plant User Interface System Having Customized Process Graphic Display Layers in an Integrated Environment" (06005/41114); "Scripted Graphics in a Process Environment" (Atty. Docket No. 06005/41115); "Graphics Integration into a Process Configuration and Control Environment" (Atty. Docket No. 06005/41116); "Graphic Element with Multiple Visualizations in a Process Environment" (Atty. Docket No. 06005/41117); "System for Configuring Graphic Display Elements and Process Modules in Process Plants (Atty. Docket No. 06005/41118); "Graphic Display Configuration Framework for Unified Process Control System Interface" (Atty. Docket No. 06005/41124); "Markup Language-Based, Dynamic Process Graphics in a Process Plant User Interface" (Atty. Docket No. 06005/41127); "Methods and Apparatus for Modifying Process Control Data" (Atty. Docket Nos. 06005/591622 and 20040/59-11622); "Methods and Apparatus for Accessing Process Control Data" (Atty. Docket Nos. 06005/591623 and 20040/59-11623); "Integrated Graphical Runtime Interface for Process Control Systems" (Atty. Docket Nos. 06005/591628 and 20040/59-11628); "Service-Oriented Architecture for Process Control Systems" (Atty. Docket Nos. 06005/591629 and 20040/59-11629).

Technical Field

[0002] A user interface for a process control system is disclosed. More specifically, a user interface for a process control system is disclosed that enables the operator to modify, configure and manipulate alarm notifications to show alarm priority, alarm age, details about a specific alarm including alarm profiles, as well as perform

alarm trending and superimposing alarm profiles over graphic displays using workstation monitors as well as handheld wireless devices.

Background of the Related Art

[0003] Process control systems are widely used in factories and/or plants in which products are manufactured or processes are controlled (e.g., chemical manufacturing, power plant control, etc.) Process control systems are also used in the harvesting of natural resources such as, for example, oil and gas drilling and handling processes, etc. Virtually any manufacturing process, resource harvesting process, including agriculture, can be automated through the application of one or more process control systems.

[0004] The manner in which process control systems are implemented has evolved over the years. Older generations of process control systems were typically implemented using dedicated, centralized hardware. However, modem process control systems are typically implemented using a highly distributed network of workstations, intelligent controllers, smart field devices, and the like, some or all of which may perform a portion of an overall process control strategy or scheme. In particular, most modern process control systems include smart field devices and other process control components that are communicatively coupled to each other and/or to one or more controllers via one or more digital data busses. Of course, many of these modern process control systems may also include non-smart field devices such as, for example, 4-20 milliamp (MA) devices, 0-10 volts direct current (VDC) devices, etc., which are typically directly coupled to controllers as opposed to a shared digital data bus or the like.

[0005] In any event, field devices include, for example, input devices (e.g., devices such as sensors that provide status signals that are indicative of process control parameters such as, for example, temperature, pressure, flow rate, etc.), as well as control operators or actuators that perform actions in response to commands received from controllers and/or other field devices. For example, a controller may send signals to a valve to increase pressure or flow, to a heater or chiller to change a temperature, to a mixer to agitate ingredients in a process control system, etc.

[0006] Obviously, in a complicated process system, a large number of different field devices are transmitting data which eventually is presented at an operator's workstation. Further, all of the field devices either directly present "alarms" to an operator's workstation or the signals transmitted by the field devices are interpreted by software which results in an alarm being sent to an operator's workstation. An operator may receive a large number of alarms during a typical shift. Because most process systems are configured so that alarms are sent in advance of the need for a corrective action as opposed to after a serious problem has been created. Therefore, because an operator may receive a large number of "preemptive" alarms during a shift, operators are often in need of ways to prioritize the alarms received at their workstations. Thus, there is a need for graphical interface software that enables operators to prioritize alarms and make choices in responding to alarms when the number of alarms being received at the operator's workstation is excessive and there are too many to be handled at once.

[0007] Another problem associated with currently available user interfaces for process control systems is the lack of contextual information about a specific alarm when the alarm is presented at the user interface or monitor. Specifically, typical

systems include an alarm banner disposed at the bottom of the screen whereby all of the information about the physical plant component and the alarm, including the date and time are presented on a single line. As a result, limited information is provided to the operator at a first glance. The operator must then manipulate the screen to receive additional information and make a judgment as to what appropriate action is needed and at what time (i.e., now or later). It would be helpful to provide an operator with improved information about a specific alarm that includes which other active alarms are present in the same control module, equipment module or operator unit. In short, there is a need for improved alarm contextual information which provides operators with additional information regarding other active alarms thereby enabling operators to better understand individual alarms in context of other active alarms.

[0008] Another problem associated with alarm signals of process control systems is, simply put, organization. Specifically, due to the large number of field devices sending alarm signals, an operator can be overwhelmed with the sheer number of alarm signals. This situation is commonly referred to as a "alarm flood." The cause of an alarm flood may be a chain reaction of problems occurring within a system. To better evaluate and take corrective action when an alarm flood is occurring, there is a need for improved organization of multiple alarms wherein the alarms are organized hierarchically with age profiles so that an operator can more easily determine the cause of the alarm flood in the "leading edge" of the alarm flood.

[0009] Another problem confronted with operators of complex systems involves the number of alarms received and the ability to anticipate problems before they occur. Specifically, there is a need for operators to provide themselves with "display alerts" that would provide operators with specific information used to augment

the alarm systems currently available. Specifically, such display alerts could be shift or session specific and could provide tactical alert information enabling an operator to anticipate problems. Such tactical display alerts could also provide one-time operational targets or help the operator ensure that the expected control system response is being achieved.

Summary of the Disclosure

[0010] In satisfaction of the aforenoted needs, a color display encoding method and software is disclosed that combines an indication of alarm priority and alarm age and allows the operator to manipulate the display of other details regarding an alarm.

[0011] In an embodiment, a disclosed alarm "detail display" combines information about a selected alarm, with information about other alarms active in the same control module, as well as parent control objects (equipment modules, units, etc.) and plant areas, including a means to navigate displays providing more information about those control objects.

[0012] In an embodiment, alarm monitoring displays are disclosed that are suitable for wireless and/or handheld devices (e.g., a "Pocket PC" or a "PDA").

[0013] In an embodiment, dynamically configurable "display alerts" are disclosed that supplement the "permanent" alarms in the process control system to monitor "one-time" conditions or operations progress. Such display alerts include, but are not limited to: "target" alerts for control parameters to assist in maintaining a constant target value (+/- an acceptable error) for a specified period of time; "range"

alerts to ensure a control parameter stays within specified limits; "ramp" alerts to ensure a control parameter changes in a linear way to a new target value and within the expected time period; and summary displays for "display alerts" for defining and identifying which alerts are running, and the current status of said alerts.

[0014] In an embodiment, hierarchical "alarm profile" displays are disclosed which are intended to point out where and when the heaviest alarm activity is taking place. Such alarm profile displays can provide a warning or indication of when operators face "alarm floods." In a refinement, the alarm profile displays can indicate active alarm counts vs. alarm age. In another refinement, the alarm profiles can include a selectable time span for: (a) all or selected alarms, (b) all or selected plant areas, (c) all or selected equipment units, and/or equipment modules. In another refinement, the alarm profile displays can include alarm summaries by alarm age, thereby making it easy to identify the still active alarms that occurred on the "leading edge" of the "alarm flood "

[0015] In an embodiment, various means for automatically superimposing alarm profiles in the form of a temporary display layer on process graphic displays are disclosed which includes means for finding graphical elements associated with control units, equipment modules, etc. so that alarm profiles can be seen in the spatial context of plant equipment schematics and in process graphical display formats that are familiar to operators.

Brief Description of the Drawings

[0016] The disclosed embodiments and methods are described more or less diagrammatically in the following drawings, wherein:

[0017] Fig. 1 is a disclosed display for a single monitor workstation environment showing an alarm banner with an expanded alarm display for a primary inlet control valve that is obtained by clicking the "i" button next to the FIC-101 banner in the lower left-hand corner of the display of Fig. 1;

[0018] Fig. 2 is a primary control display for the valve FIC-101 that is obtained by pressing the FIC-101 button disposed in the lower left-hand corner of the display illustrated in Figs. 1 or 2;

[0019] Fig. 3 is an expanded view of the floating panel in the upper left portion of the display of Fig. 2 which is expanded by clicking on the set point value (680) shown in the floating display of Fig. 2 and which enables the operator to enter a new set point value in the space provided;

[0020] Fig. 4 is an illustration of a disclosed three monitor workstation environment with various floating displays designed in accordance with this disclosure;

[0021] Fig. 5 is another view of a three monitor workstation environment illustrating various examples of watch panels on the left and right and specific alarm information in the central panel;

[0022] Fig. 6 is an illustration of a display for a hand-held PC, pocket PC or personal digital assistant ("PDA") device;

[0023] Fig. 7 is an illustration of a display for a PDA device with various alarms indicated thereon;

[0024] Fig. 8 is another illustration of a graphic display for a PDA device displaying specific alarm information for the inlet flow control valve illustrated in Figs. 2 and 3;

[0025] Fig. 9 illustrates a graphics display for a single monitor workstation environment showing an alarm related to the primary inlet flow valve identified as FIC-101 but where the object upstream pump identified as VSPMP-101 has been clicked on to provide further information as the alarm cause is being investigated;

[0026] Fig. 10 illustrates the graphic display as a result of the actions taken by the operator in connection with Fig. 9 wherein details relating to the pump VSPMP-101 are provided;

[0027] Fig. 11 is an illustration of a graphic display whereby an operator has established a "target" alert of 720° for a reactor tank TI-101 with an acceptable deviation of +/- 5° for a duration of one hour.

[0028] Fig. 12 is a graphic display of a "range" alert whereby the operator knows a particular stream flow should fall within the range of 110 to 115 gpm and has set an alert to go off in the event the flow falls outside of that range;

[0029] Fig. 13 is a graphic display of a "ramp" alert to check for a steady ramped or increased volume measurement within a holding tank over a period of 12 hours so that the level within the tank rises to 360 inches;

[0030] Fig. 14 is another graphic display summarizing the target, range and ramp alerts described above in Figs. 11-13;

[0031] Fig. 15 is an enlarged view of the summary of the target, range and ramp alerts illustrated in Fig. 14;

[0032] Fig. 16 is an expanded view of a summary of the ramp alert illustrated in Fig. 13 at a subsequent time to that illustrated in Fig. 15;

[0033] Fig. 17 is an expanded view of the ramp alert illustrated in Fig. 13 at a subsequent time to those illustrated in Figs. 15 and 16 as the goal of 360 inches is at or near completion;

[0034] Fig. 18 is a graphic display for an alarm profile summary that indicates active alarm counts, stacked by priority and charted over a previous time period;

[0035] Fig. 19 is an illustration of a graphic display for an alarm profile for a specific area "A" which includes two reactors and a separator as shown;

[0036] Fig. 20 is a graphic display where an advance display button features has been clicked on and alarm summaries are presented on top of a schematic illustration of the process control area;

[0037] Fig. 21 is an example of a trend display for a control valve that illustrates an abrupt decrease in flow within the past hour;

[0038] Fig. 22 is another graphic trend display for the same control valve illustrated in Fig. 21, but over a two hour time period as opposed to a one hour time period;

[0039] Fig. 23 is a manipulated display showing the same data of Fig. 21 to identify a minimum flow value and when the minimum flow value occurred;

[0040] Fig. 24 illustrates the flow drop over a period of four minutes and 45 seconds for the control valve illustrated in Figs. 21-23;

[0041] Fig. 25 is another graphical presentation of the drop in flow rate illustrated in Figs. 21-24;

[0042] Fig. 26 is a comparison of the drop in flow rate for the valve illustrated in Figs. 21-25 with the flow rates of two other valves over the same time period; and

[0043] Fig. 27 is a further manipulation of the display shown in Fig. 26 used to analyze the data over a more discreet time period.

[0044] It should be understood that the figures are not to scale and that various graphical displays are illustrated in partial, diagrammatic and fragmentary views. In some figures, details may have been omitted which are not necessary for an understanding of this disclosure or which render other details difficult to perceived. It should be understood, of course, that this disclosure is not limited to the particular embodiments or graphical displays illustrated herein.

Detailed Description of the Presently Preferred Embodiments

[0045] Turning to Figs. 1 and 2, a single monitor workstation graphic display is illustrated wherein the screen 10 includes an alarm panel 11, a system status panel 12, a main display area 13, a tool-panel 14 and a selector panel 15. In the screen 10 shown in Fig. 1, the alarm panel 11 indicates a moderate priority alarm for the control valve identified as FIC-101 and with an object shown at 16 in Fig. 2 which is a primary inlet to the reactor 17, also shown in Fig. 2. The alarm is indicated at 18 in Fig. 1. In an embodiment, the color of background of the alarm panel 11 may indicate when the alarm was activated. For example, a white or clear background could be used for very recent alarms while colored backgrounds could be used for alarms that have been active for an excess of one hour and a dark or black background could be used for alarms that have been active for eight or more hours. The summary shown in the alarm banner 11 for FIC-101 is created by clicking the "i" button 21 next to the indicator 22 in Figs. 1 and 2. For additional information, the operator can click the "i+" button 23 in Fig. 1 to produce the floating display 24.

[0046] The display logic for the button 23 captures the module name "FIC-101" for the alarm currently selected in the alarm banner 11 and constructs a calling informational string of "Display='DvAlarmInfo'; Module='FIC-101'" and then passes it on to the workspace function "OPEN_DISPLAY." The DvAlarmInfo display was configured with a panel category of ALARMINFO. In the framework utilized herein, there is a single floating panel configured to be an ALARMINFO category target so that the floating panel is chosen for the DvAlarmInfo display. If another display is currently open, it is closed to open the display 24 as shown in Fig. 1 when the button 23 is pressed.

[0047] The display logic in a "DvAlarmInfo" display such as that shown at 24 in Fig. 1 requires a module name for it's launch information. Finding "FIC-101", it uses that name in calls to the data services layers to obtain information about the valve 16 labeled FIC-101 (see Fig. 2) and it's containing unit and equipment modules. With an understanding of the alarm situation in valve FIC-101, and its related modules, the operator closes the "DvAlarmInfo" floating panel 24, and looks at the primary control display for FIC-101 as shown in Fig. 2, by pressing the button 22 in the alarm banner 11.

[0048] Still referring to Fig. 2, by way of example only, the display logic for the alarm banner 11 buttons captures the module name ("FIC-101") and constructs a calling info string of "Panel='MAIN'; Module='FIC-101'; Select="FIC-101"; KeepARScrollOneDim", and then passes the string to workspace function "OPEN_PCD". The OPEN_PCD function resolves the primary control display name "REACTOR1_TOP" for module "FIC-101". It then asks the workspace to resolve PANEL='MAIN', and to replace the display currently in that panel with REACTOR1_TOP. REACTOR1_TOP originated through an import of a P&ID drawing

from another system, so it's native aspect ratio is much wider than the MAIN panel 13 in the current framework. A "KeepARScrollOneDim" directive says that the aspect ratio for REACTOR1_TOP should be maintained while scaling it to fill the MAIN panel 13, with scroll bars for portions of the display that wont fit.

[0049] The Select="FIC-101" directive is forwarded to "REACTOR1_TOP" telling it to resolve the "best" selectable graphic object associated with "FIC-101" and automatically give it selection focus (scrolling the display as necessary so the selected object is visible and as centered in the MAIN panel as possible.) The presence of the "KeepARScrollOneDim" and "Select" directives overrides the default workspace behavior which remembers the scaling and scroll position last used on a display, for when it is opened again in the same user/session.

[0050] After looking at "near by" alarm conditions and process measurements, the operator chooses to make an adjustment to the setpoint on FIC-101, and watch how that control loop reacts. The faceplate display 25 shown in Fig. 2 is the ideal interface for what the operator has in mind, so he pushes the FIC-101 button 22 which is still in the alarm banner 11. The display logic for the faceplate button 22 captures the module name ("FIC-101") associated module, constructs a calling info string of "Module='FIC-101'", then passes it to workspace function "OPEN_FPD".

[0051] The OPEN_FPD function resolves the faceplate display name "PID_LOOP_FP" for module "FIC-101". The "PID_LOOP_FP" display 25 was configured with a panel category of "FP". In the current framework, there are two floating panels configured to be an "FP" targets, both are currently empty, so floating panel 25 on the left is chosen as it was placed ahead of the other floating panel in the

floating panel "use order" configuration. An instance of the PID_LOOP_FP display 25 is opened there, passing it the launch information: "Module='FIC-101'".

[0052] The display logic in the "PID_LOOP_FP" display 25 expects a module name to be in it's launch information. Finding "FIC-101", it uses that name in calls to the data services layers identify the parameters in FIC-101 it will be reading. Several parameter/field values from the valve FIC-101(see 16 in Fig. 2) are used repeatedly in the FIC-101 display 25, most notably the scaling parameter associated with the pressure value "PV" and system pressure "SP" parameters. The "pre-update" logic for "PID_LOOP_FP" read the EU0 and EU100 values, engineering units string and decimal places information and stores them in "local display variables" which can be referenced by any of the graphic elements in "PID_LOOP_FP". In short order, a new instance of "PID_LOOP_FP" appears in the floating panel initially located at its anchor point.

[0053] Turning to Fig. 3, if the operator thinks a significant system pressure change is appropriate and using the nudge up 26 or down 27 buttons won't do, the operator can push on the button 28 indicating the set point value. The display logic for the system pressure button 28 click is to ask the workspace to provide a standard numeric data dialog. The "PID_LOOP_FP" display 25a of Fig. 3 is designed to also be used in workspaces running on PDAs, so it constructs a parameter info string of "InParentDisplay; DockBottom; Title='FIC-101/PID1/SP.CV'" and passes it to the workspace function "NumericDataEntry". The NumericDataEntry workspace function sees that the workspace was launched with a "ShowKBOnScreen" preference (perhaps running on a hardware where the keyboard is not always present), so it chooses an instance of the standard numeric data dialog with an on screen keypad. The workspace

resolves the dimensions and location of this instance of the PID_LOOP_FP display, and locates the dialog box at the bottom of the faceplace display.

[0054] The operator can enter a new value for the setpoint in the box 29. The operator then sees the new value for setpoint reflected in the value shown on the setpoint button 28 and is assured that the controller is now using/reporting the new setpoint value. The mode shown in Fig. 3 is in AUTO so the confirms some changes in the control (valve) output, and shortly thereafter the pressure starts moving in the desired direction.

[0055] In Fig. 4, the operator can use a three monitor workspace with screens 10a, 10b, 10c. When a new alarm appears in the alarm banners 11b or 11c, the operator can recognizes the "tag" appearing in the banner and can confirms the module description. To correct a problem upstream of FIC-101(see Fig. 2), the operator can push the left faceplate button 31 in Fig. 2 to view upstream components. With a three monitor display of Figs. 4 and 5, the operator can put a copy of the upstream display in one of the empty panes 32-35 in the left monitor screen 10a. To accomplish this, the operator pushes the "copy panel content" button 36 in the toolbar 14b over the main panel 10b. The display logic behind the copy panel content button 36 prepares a parameter information string of "Panel=MAIN" and calls the workspace function CopyPanelContent. The Copy PanelContent function captures the display name currently in the specified panel, the launch information used to create that display, and the current scaling, and scroll position settings.

[0056] The operator then pushes a "paste" button, e.g., 37, in the combined information and tool button bar 38 of an empty panel, for example the panel 33, of the left monitor or screen 10a. The paste button 37 essentially prepares a parameter

information string of "Panel='<my panel id>'; UseSourceScale", and calls the workspace function that "paste copied panel contents" to "this" panel (in this case 33). The new instance of the display, with the original launch information is opened in the panel 33. The scaling of the source display is preserved, but since the panel is half the size of the source panel, the view is centered on the center point of the source view, and horizontal and vertical scroll bars appear.

[0057] Turning to Fig. 6, an operator or operations supervisor monitor the system using a PDA 40. As shown in Fig. 7, the operator can keep the "TOP_ALARMS" display open in the main panel 41. The TOP_ALARMS display can be closed by pressing the "Top" button 42 in the toolbar panel 43 as shown in Fig. 7.

[0058] In Fig. 8, the PDA 40 produces an alarm banner 44 and, optionally, a warning-level alarm sound. The operator can push the "i+" button 45 to check for other alarms in this module, equipment module, and unit. The display logic for the "i+" button 45 of a PDA 40 is designed to call up the ALARMINFO display for the selected module. Normally the ALARMINFO display would be retrieved from the DEFAULT subtree under the display configuration storage root directory. However, this workspace was started with the launch information "DisplayPref=PDA", so it will attempt to find a display definition named ALARMINFO in subtree named PDA, before looking for it in the DEFAULT subtree.

[0059] Returning a single workstation as shown in Fig. 9, as one example, the operator has been noticing intermittent deviation alarms on the primary inlet flow control loop for reactor 1 (RXTR 1). Observing the primary control display for reactor 1, an operator could conclude that the deviation alarm occurs when demand peaks for a few minutes as a result of new production rates. To retrieve information on the inlet

flow feed pump VSPMP-101, the operator clicks on the graphic object 51 representing the pump VSPMP-101 to generate the display of Fig. 10. The pump object 51 in the display of Fig. 9 may be taken from a standard library of graphic objects and can be configured to be a selection target, and when selected, to indicate selection with a dashed box around the pump VSPMP-101 as shown in Fig. 9 and the pump's tag string, and also to make the button visible that opens the runtime object browser application. Clicking on the pump VSPMP-101 or object 51 around the pump VSPMP-101 gives feedback that it is selected in the form of Fig. 10, and the object browser button appears.

[0060] In Fig. 10 the operator can review various information about the pump VSPMP-101. The first section 53 has information about the specific pump including location, ID tag number, and physical specifications. A button 54 is available here to open the "Operations Journal" application for the pump VSPMP-101. Another button 55 is provided to access the Asset Management Solutions (AMS) software data for the device VSPMP-101. The second section 56 contains information about the type and class of pump including buttons 57-60 to access the manufacturer's operating guidelines documentation, drawings, or identification pictures, and training documents such as standard procedures such as operating and maintenance procedures. The third section 61 provides location information and the fourth section 62 allows the operator change the display 10 to other upstream or downstream objects.

[0061] Figs. 11-17 illustrate the use of target alert, range alert and ramp alert alarm profiles. For example, if the operator had just finished responding to an alarm by making a setpoint change and was satisfied the change was accepted by the controller, the operator may want to monitor the primary control display for this change but is unable to because of other alarms. The use of a display alert may be helpful in

alleviating this problem. Turning to Fig. 11, if a temperature setpoint change is going to take an hour to raise the temperature on the product in reactor 1 (see Fig. 9) to the new target of 720°F, the operator can start a target alert by clicking on an "Add Display Alert" button 71 in the toolbar panel 14 over the main panel 10 showing the control display for reactor 1 causing the display alert dialog box 72 to appear as shown in Fig. 11.

[0062] If the operator desires "target alert" he or she selects tab 73. The parameter that needs to be set for the alert on is already inserted into the box 74 due to the process change. The operator sets an initial delay of 1 hour by appropriately filling in the box 75, before checking that the target value of 720° has been reached. A different target value may be entered in the box 74 if necessary and an acceptable deviation band (+/- 5 degrees) is entered into the box 76. The alert check duration of 1 hour (making sure the temperature doesn't drop or overshoot for at least an hour after the target is achieved) is entered into the box 77. If the operator doesn't have anything more to do when this alert is removed, the "acknowledge" box may be cleared. The remaining boxes in the display 72 are self explanatory and will not be described in detail here. When finished with the target alert, the operator hits the "add display alert" button 79. The display 72 closes and a runtime workspace adds the new display alert. In an hour, the controller will start checking that the value for TI/101-2/AI1/IN.CV is 720 (+/- 5) degrees, and continue for the next hour. After that point, the target alert shown in Fig. 11 will automatically remove itself.

[0063] Turning to Fig. 12, a range alert may be desired to check in change in output or throughput. After clicking on the button 71, the dialog 72 appears, but operator can switch to the range alert tab 81 as shown in Fig. 12. If a flow rate of 112

gpm is desired, the operator can set upper and low range limits in the boxes 82, 83 for the display alert. If a flow rate of 112.2 gpm has already been established so there is no need for an initial delay on the display alert and the boxes 84-86 are left blank. Also, if the product is to be made for an extended period of time exceeding a shift change, the boxes 87-89 can be left blank as well and clicking on the button 79 can institute the range alert.

[0064] A ramp alert is illustrated in Fig. 13. If a large tank needs to be filled, the operator can pull up the tank farm process display, and uses the object browser application to get the link to the product movement procedure checklist. After manually opening and closing the appropriate block valves, the operator can start the pump and verify a steady flow measurement as the product is transferred to the tank. In Fig. 13, a ramp alert is set for a plan to achieve a level of 360 inches (see box 95) in the destination tank that level will be achieved in 12 hours (see box 96) based upon a target flow rate.

[0065] With no discharges planned, operator expects a steady increase of the level of the tank from its present measurement, to the target over the next 12 hours. Rather than set a target alert (with no checking going on for 12 hours), a ramp alert can be chosen instead by clicking on the tab 91 to check for a steady "ramped" measurement throughout the next 12 hours. Since the next shift operator will need to shut off the transfer pump and close valves, the current operator checks the "acknowledge before removing" box 92 so the completed alert will get the next operator's attention. The operator also adds a comment in box 93 to remind the next operator what needs to be done.

[0066] To check the display alerts described in Figs. 11-13, the operator presses a "display alerts status" button 102 in the tool bar 14 (or alarm banner panel 11 or elsewhere). This button 102 replaces the content of the main panel 10 with the display alerts status application shown in Figs. 14 and 15, where the three display alerts of Figs. 11-13 are summarized. Comparing Figs. 14 and 15, the target flow rate of 110-115 gpm of Fig. 12 is not being achieved at the point in time represented in Fig. 15 thereby producing a warning indicator 103 while the target rate was being met in Fig. 14. Also, the target temperature of 720° set in Fig. 11 was not met in Fig. 14 but met in Fig. 15.

[0067] As shown in Figs. 14 and 16, during a subsequent shift, the new operator may push the display alerts status button 102 (Fig. 14) to review what the previous shift had left him. Fig. 14, would show a single display alert left over, so the operator presses the show details button 104 to get the information shown in Fig. 16 indicating a level of 315 inches in the tank, still short of the desired 360 inches.

[0068] After a couple of hours, the operator would notice a display alert indicator in the alarm banner 11 area had turned white and began flashing. After opening the display alert status display, the display of Fig. 17 would appear to indicate that the ramp alert of Fig. 3 has been completed, and requires acknowledgment. The operator would then acknowledge the completed display alert and press the button for the primary control display for LI-TF1-PRD23 so that the transfer pump can be stopped and the transfer valves reset.

[0069] Figs. 18-20 illustrate disclosed techniques for responding to alarm floods. As will be apparent to those skilled in the art, new alarms can be produced faster than the operator can keep up with. The operator can push a button 110 in the toolbar

panel 14 for the "alarm profiles" application which would appear in the main panel 13 replacing the previous display as shown in Fig. 18. The alarm profile charts indicate active alarm counts, stacked by priority, and charted over the previous hour. The top chart 111 shows the active alarm profile for all active areas under the operator's control (or alarm management scope), and automatically shows charts for each of the five most active plant areas, four of which are shown at 112-115. From Fig. 18, it is clear that area "A" (chart 112) is problematic, so the operator may press the "expand" button 116 for that area to produce the more detailed charts of Fig. 19.

[0070] In Fig. 19, the chart 112 of Fig. 18 becomes the upper chart in Fig. 19, with the charts for the five most active units/equipment modules in the plant area disposed below the chart 112, three of which are shown at 117-119. Fig. 19 shows that nearly all the new alarms are coming from the reactor 1 unit in chart 117. By pushing the "list alarms" button 121 for reactor 1, a list of all active alarms associated with that unit that occurred within profile time window (the previous hour) appears in the right side of the display in Fig. 19. Using the "i+" buttons 122, the DvAlarmInfo display for the alarms can be opened for full details. To get a another view on the alarm profile for reactor 1, the operator can press the "primary control display" button 123 for reactor 1 to produce the display of Fig. 20.

[0071] The "advanced display features" button 124 on the toolbar panel 14 enables to operator to select "add alarm profiles." This causes the runtime workspace to find the graphic elements associated with unit and equipment modules, their location on the screen, and creates a temporary display layer for the existing display which shows active alarm profiles for each major equipment grouping. The other layers in the display

are subdued or semi-transparent to make the alarm profiles easier to see as shown in Fig. 20.

[0072] Fig. 21 is a trend pop-up for a valve showing a distinct drop in flow rate about 1 hour ago. To check the value for a longer time period he clicks on the period button 130 in the control bar 131, and it cycles to a 2 two hour view as shown in Fig. 22. Using the keyboard arrow keys or a mouse to place the cursor back a couple of samples until the "minimum value" icon 132 appears in the legend bar 133, the operator can find and display the low point of the curve as shown in Fig. 23. As shown in Fig. 24, the slope of the downward curve can be calculated by placing another vertical bar 134 in the appropriate place as shown before the low point vertical bar 135. The flow through one valve FIC-102 may be compared and contrasted with the flow through related valves FIC-108 and FIC-112 as shown in Figs. 25-27.

[0073] It will be noted that the placement of various buttons, displays, toolbars, alarm banners, system status banners, etc., are relatively arbitrary and their placement may be modified substantially without departing from the spirit and scope of this disclosure. All of the graphic layouts disclosed in Figs. 1-27 are exemplary and for purposes of illustration and are clearly not intended to limit the spirit and scope of this disclosure or the appended claims.

[0074] As a result of the displays shown in Figs. 1-27, the operator is provided with a clear graphical interface that combines an indication of alarm priority and alarm age and allows the operator to manipulate the display of other details regarding a specific alarm or alarms. Information regarding a selected alarm may be combined with information from other alarms and equipment data. Further, the graphical displays are applicable to PDA devices for use by supervisors as well as

operators. Various types of display alerts and hierarchical alarm profiles are also provided to improve the effectiveness of plant operators.